

The USGS National Land Imaging Program Update for the NGAC

Tim Newman

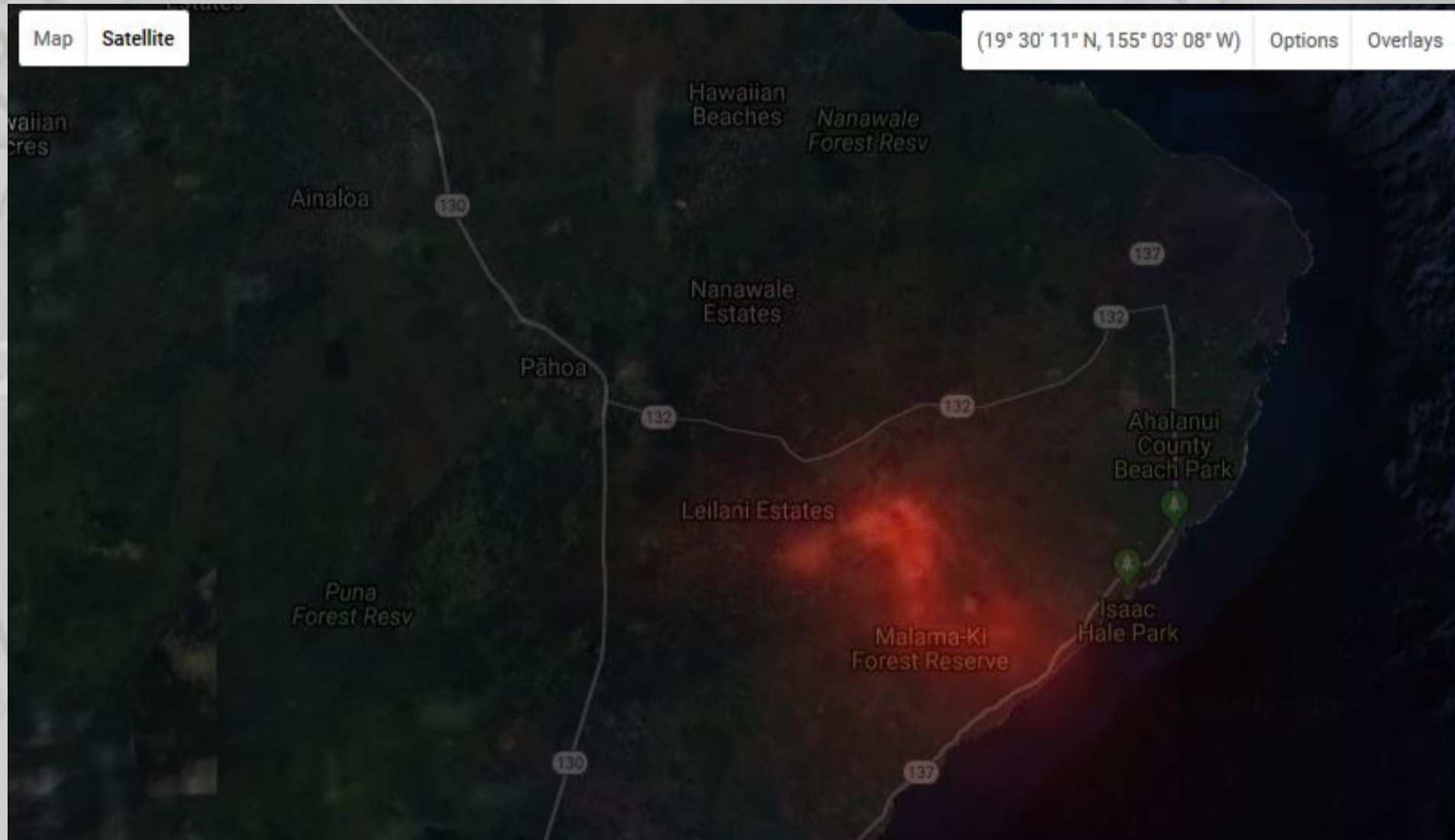
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27 June 2018

Landsat 8 Operational Land Imager Off-Nadir Ascending Image – Kilauea, May 2018

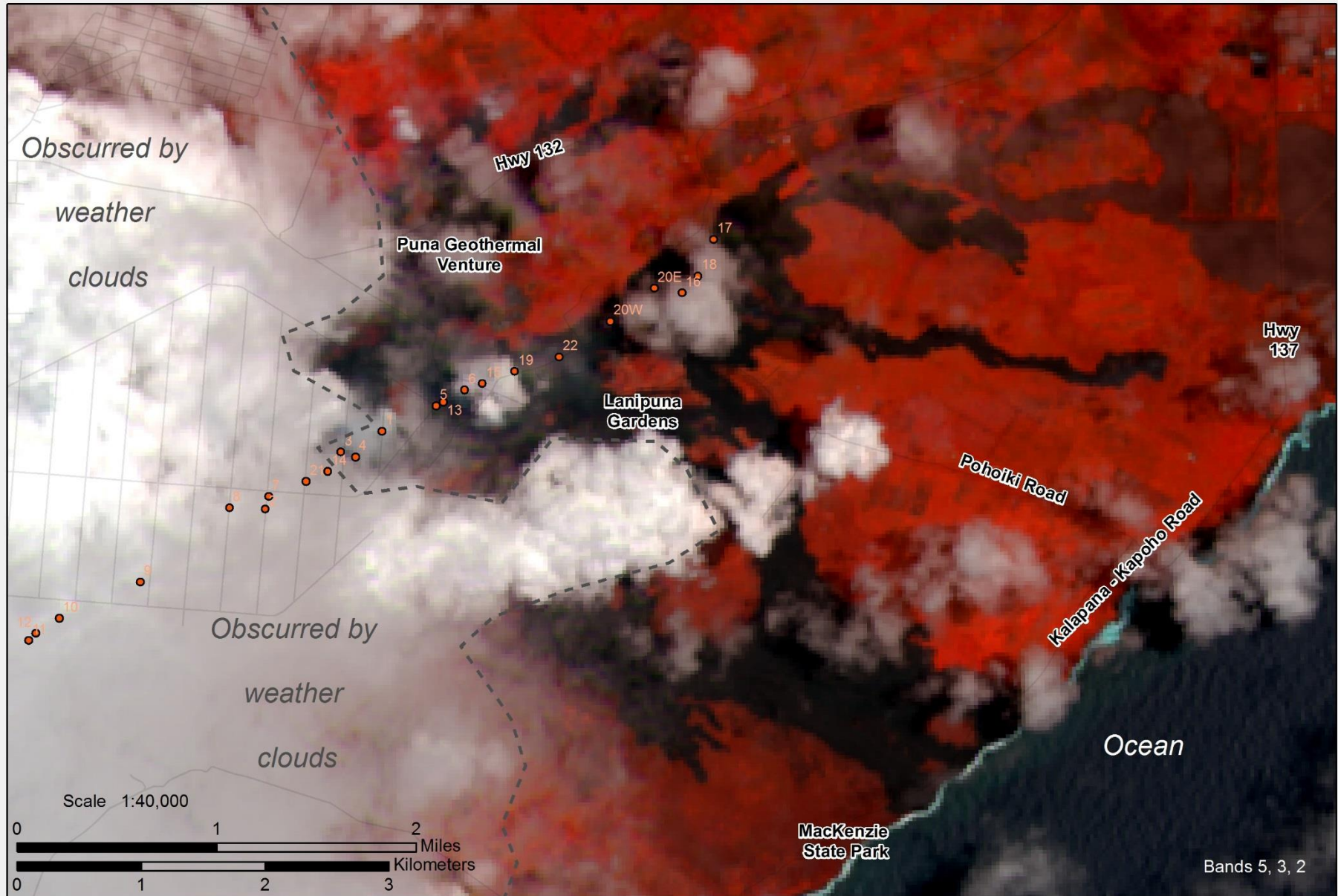


Landsat 8 OLI Nadir Ascending Image – Kilauea, May 2018



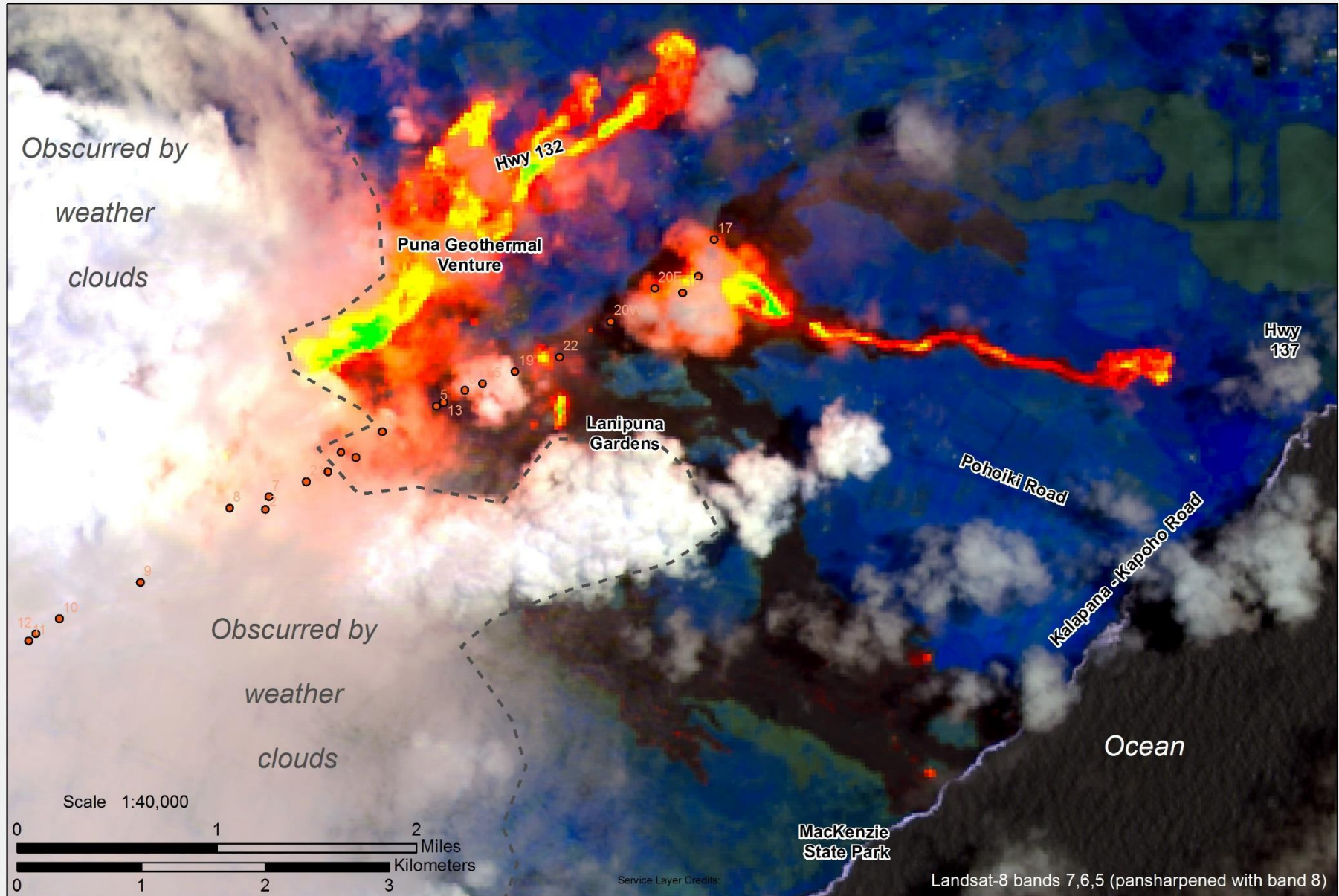
Kilauea Volcano and the Lower East Rift Zone

Landsat-8 for May 30, 2018 Near-infrared



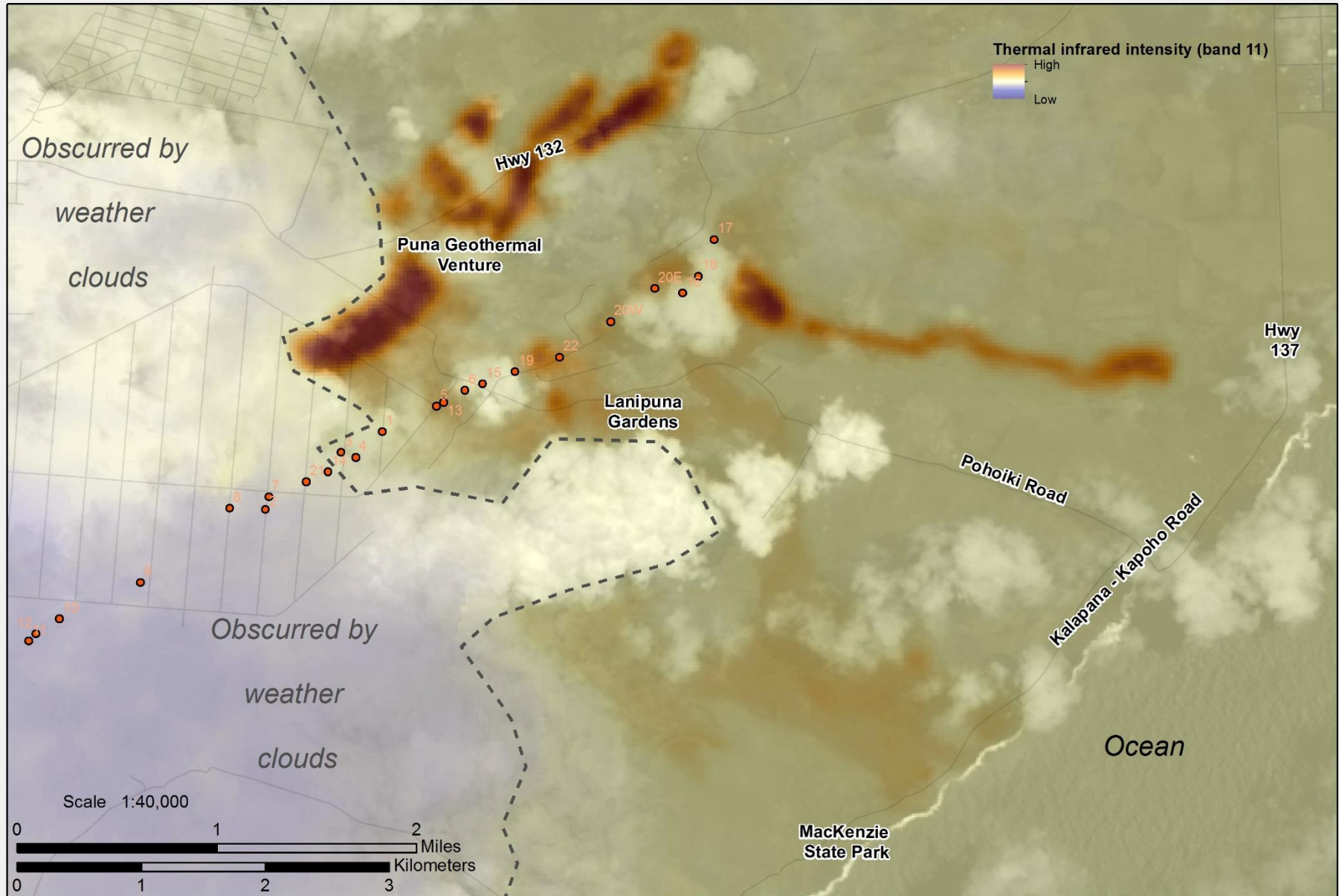
Kilauea Volcano and the Lower East Rift Zone

Landsat-8 for May 30, 2018 (short-wave and near infrared)



Kilauea Volcano and the Lower East Rift Zone

Landsat-8 for May 30, 2018 (thermal infrared)



DOI Unmanned Aircraft System Flights Supporting the Kilauea Volcano Activity



A History of Landsat Capabilities

L 1-3



- 80m Resolution
- 2 Instruments
- MSS, RBV
- 4 Bands
 - Green
 - Red
 - 2 NIR
- 6-bit precision
- 18-Day Revisit

L 4/5



- **30m** Resolution
- 2 Instruments
- TM, MSS
- **7 Bands**
 - **Blue**
 - Green
 - Red
 - 2-NIR
 - **SWIR**
 - **TIR (120m)**
- 8-bit precision
- 16-Day Revisit

L 7



- 30m Resolution
- 1 Instrument
- ETM+
- **8 Bands**
 - Blue
 - Green
 - Red
 - 2-NIR
 - SWIR
 - TIR (60m)
 - **Panchromatic (15m)**
- 8-bit precision
- 16-Day Revisit
- Improved On-board Calibration
- Solar Calibration

L 8/9



- 30m Nominal Resolution
- 2 Instruments per satellite
- OLI, TIRS / OLI-2, TIRS-2
- **11 Bands**
 - **Coastal Aerosol**
 - Blue
 - Green
 - Red
 - NIR
 - **2-SWIR**
 - **Cirrus**
 - **2-TIR (100m)**
 - Panchromatic (15m)
- **12/14-bit precision**
- **Improved SNR**
- **Improved spectral bandpass**
- 16-Day Revisit
- On-board Calibration
- Solar Calibration
- **Lunar Calibration**

Landsat Operations and Development Status

Landsat 7 (1999-)

- Collecting about 475 new scenes per day; latest fuel estimate projects operating into 2021

Landsat 8 (2013-)

- Collecting up to 725 new scenes per day; together with Landsat 7 supports 8-day revisit

Landsat 9 (December 2020 launch)

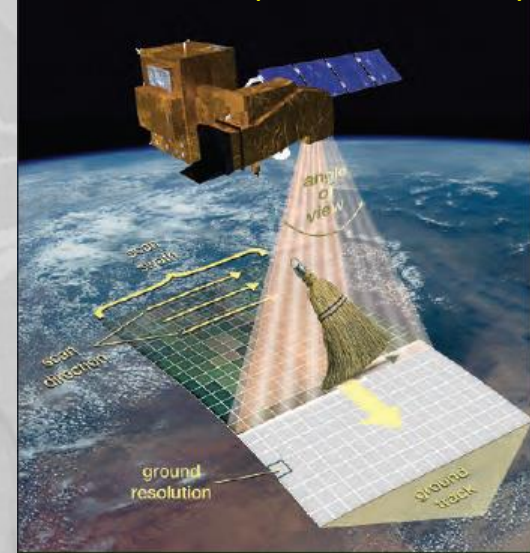
- Essentially a copy of Landsat 8, but with important improvements for accuracy and resiliency
- Upgrade to fully Class B (Thermal IR instrument was a Class C instrument on Landsat 8); 14-bit data

Landsat 10 (~2025-2030 launch)

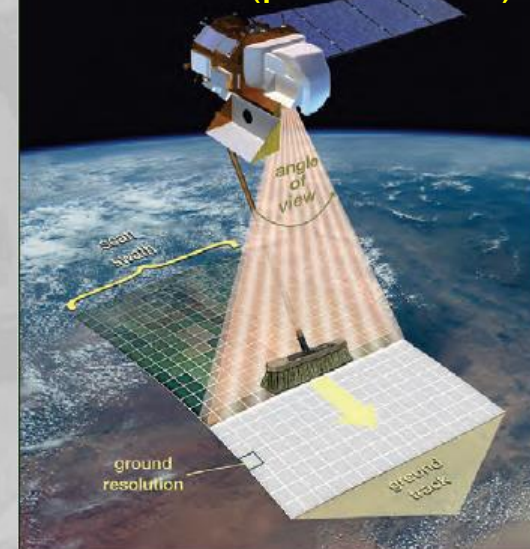
- Technology and user needs studies underway to support an architecture study to commence in 2018
- Everything is on the table at this point (e.g., smallsats, hyperspectral, data buys, Public-Private Partnerships)



Landsat 7 (whiskbroom)



Landsat 8 (pushbroom)



Sustainable Land Imaging (SLI)



- Collaboration between NASA and DOI/USGS that enables the **development of a multi-decade**, spaceborne system to provide users with high-quality, global, land-imaging measurements compatible with the existing 45-year record
 - **Landsat 9 is the first SLI Mission**
 - **NASA and DOI/USGS collaborate in developing program strategy and architecture**, identifying user needs, and defining mission requirements
 - **SLI Joint Steering Group** – Chaired by NASA Associate Administrator for Science and Interior Assistant Secretary for Water & Science – meet periodically to coordinate and integrate SLI efforts, and to enable overall program strategy generation and approval
- Under the SLI program, NASA and DOI/USGS work together to ensure sustained access to land remote-sensing observations for U.S. research and operational users

Landsat 10 Planning under SLI

- Under SLI, USGS is working with NASA on early Landsat 10 planning activities, including requirements and technology development, to reduce cost and risk in future missions
 - USGS is partnering with Federal agencies and others to document the uses of and requirements for land imaging data
 - NASA is conducting instrument reduction studies, business model studies and other technology investigations to reduce cost and risk in next-generation Landsat missions
- USGS and NASA will continue to work together, leading to an initial joint-agency decision as early as 2019 on the Landsat 10 system architecture, with launch projected in the mid-late 2020s
 - Everything is on the table at this point
 - Measurements must enable backward and forward assessments

Future Landsat systems need to ensure Earth Observation Continuity; USGS and NASA are open to new technologies, business approaches

2013-2014 SLI Architecture Study Team (AST)

Land Imaging AST Charge

- Define a **global, Sustainable Land Imaging (SLI) system for a 20-year period** starting in 2018
- Provide cost effective options for near-term capabilities, continuity risk mitigations, technology infusion
- Consider refined capabilities requested by the user communities
- **Include new measurement approaches & potential international and private sector partnerships**

AST Study Process

- Established study trade space via expert knowledge, intensive AST discussions, and RFI responses
- Explored alternatives via several design cycles

Key AST Finding → A Landsat 8 rebuild for Landsat 9 had the lowest technical risk

- Consistent with Congressional and Landsat community desires; direct data continuity with Landsat 8
- **Enables several years for SLI to prepare for efficient implementation of future technologies**

Space-based Systems						
Instrument Configuration	Spacecraft Platform	Risk Class	Launch Vehicle	Potential Technology Infusion	Partnerships	Business Models
3+ Separate Instruments	Dedicated Spacecraft	Class B	Dedicated	Hyperspectral	International	Separate Contracts
Two Separate Instruments	Hosted Payload	Class C	Shared	Micro-bolometer	Commercial	Observatory Contract
Combined Instrument	Minisat/Microsat Constellations	Class D+		Enabling Instrument Technologies	Federal Agencies	Commercial Practices SC + LV
						Hands Off Turn-Key
						Block Buys
						Data Buy
						Sole Source
						IOO Space

Phase 1 of the first AST started with ~500 architectures

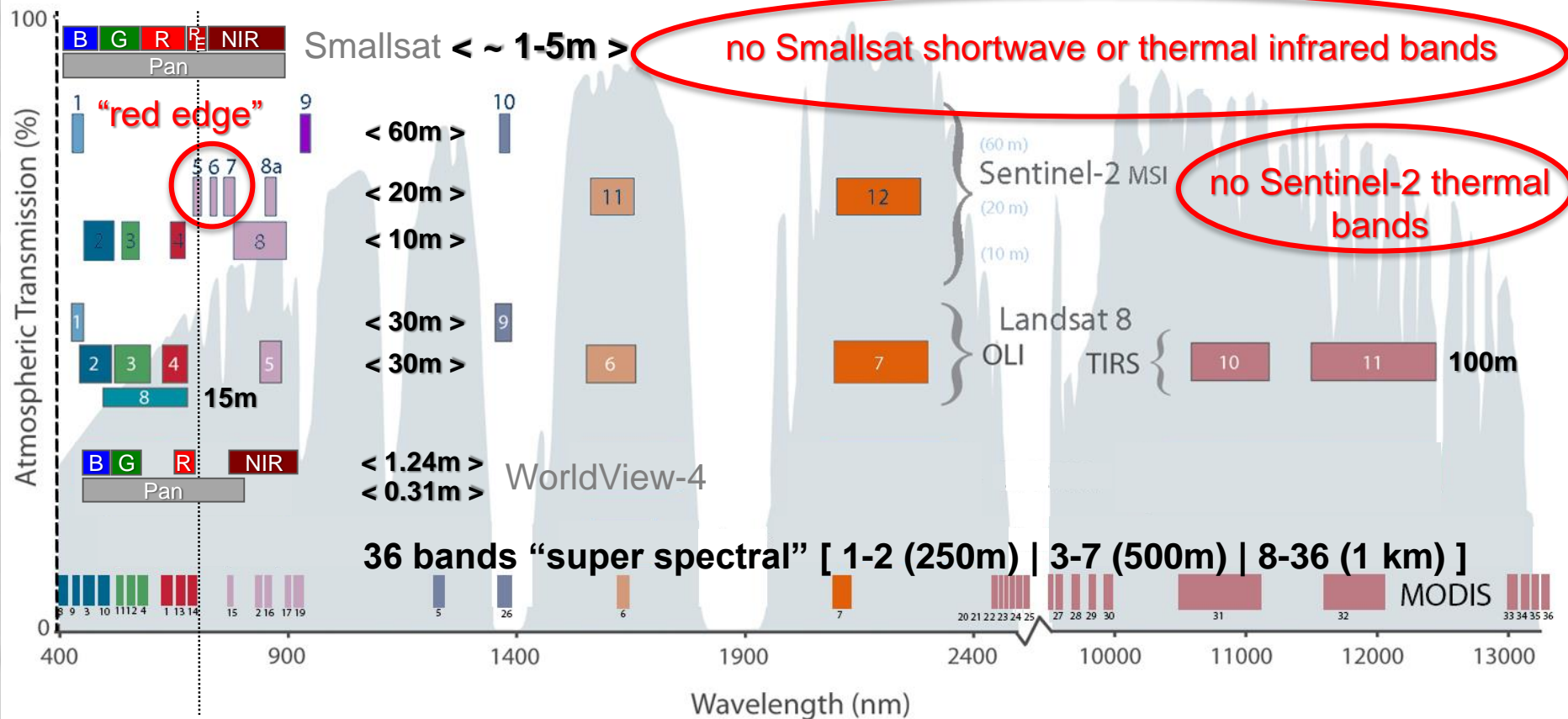
2018-2019 SLI Architecture Study Team

- New architecture must incorporate existing and future capabilities of the international and private sectors
 - ESA Sentinel-2 missions expected to operate well into the 2030's
 - India's space agency has a long-running Earth observing program
 - Planet, DigitalGlobe and other commercial firms are continuing to improve their capabilities and products
 - The Joint Agency Commercial Imagery Evaluation (JACIE) collaboration continues to monitor and assess commercial offerings
- New architecture must incorporate improving technology
 - More capability on smaller satellites to reduce space segment costs
 - Improved “lossless” compression to reduce data volume, and store and deliver products
 - Improved product offerings and packaging to reduce product sizes
 - User-defined areas of interest, spectral subsets, information products
 - Utilization of commercial cloud provider resources to house, process and disseminate basic and higher-level products to users

But the bottom line for the architecture is it must meet the user needs!

Spectral Considerations for the SLI Architecture Study

		Landsat	Sentinel-2
inclination	(deg)	98.22	98.56
orb height	(km)	705	786
period	(min)	98.8	100.65
swath	(km)	185	290
revisit	(day)	16	10



Backup Slides

National Land Imaging Program Components

Satellite Operations

Develop and operate systems to acquire, produce, preserve, and deliver products and services to meet civil Earth observation research and operational requirements

- Collect, archive, process & disseminate Landsat & Landsat-like data (Landsat 1-8, S-2)
- Operate the Landsat 7 and 8 satellites, calibrate and validate the incoming data
- Develop the Landsat 9 ground system in concert with NASA for 2020 launch
- Collect, maintain and analyze user requirements; inform 2019 Landsat 10 decision

Science, Research & Investigations

Conduct science, research and technology investigations to improve upon and develop new products and services

- Applied science & applications, including drought monitoring, global cropland estimates
- Remote sensing research and development, including unmanned aircraft systems

Manage National Civil Applications activities

- Provide National Security Space system geospatial data supporting USGS applications
- Facilitate Federal civil agency use of these systems via Civil Applications Committee

Fundamental goal: Ensure public availability of a primary data record about the current state and historical condition of the Earth's land surface



What is Landsat?

Our longest-lived series of land imaging satellites, providing a 45+ year archive of natural and human-induced changes to the global landscape, informing land and natural resource management decisions, and helping us understand Earth system change



Multi-spectral coverage in VNIR-SWIR-TIR

➤ to map surface composition & temperature

15 / 30 / 100 meter spatial resolution

➤ to resolve human-scale land dynamics

16-day revisit frequency (8-days w/ two operational satellites)

➤ global, seasonal coverage

Broad area collection => 12,000+ square miles per image

➤ 1200 images/day = 15 million sq. miles/day (40 million sq. km)

Highly calibrated “science quality” data

➤ to resolve long-term trends & retrieve biophysical variables

Free and Open Data policy since 2008

➤ 20 million products distributed by USGS last year

Common Uses of Landsat data by Federal Agencies, States, and the private sector:

- | | | |
|------------------------------|----------------------------|---------------------------|
| ● Agriculture and Forestry | ● Water Resources Planning | ● Famine Early Warning |
| ● Regional Land Use Planning | ● Global Change Science | ● Carbon Assessment |
| ● Mapping | ● Flood Management | ● Drought Monitoring |
| ● Fire/Disaster Management | ● National Security | ● Transportation Planning |
| ● Land Use/Land Cover | ● Ecosystem Monitoring | ● Calibration/Validation |

Landsat Users and Applications

Landsat is the most impactful land imaging satellite data source across Federal civil agencies

Users:

- **Federal Agencies (USDA, EPA, DOI, NASA, DOD, NOAA)**
- State Agencies (Planning, Natural Resources, Transportation)
- University Researchers
- International Organizations (UNEP, WCRP, FAO, EC JRC, CSIRO, GA, DLR)
- Non Governmental Organizations (TNC, WRI, WWF, Resources for the Future)
- **Commercial (Exxon-Mobil, MapBox, Descartes Labs, ESRI, Gallo, Harris Corp, ITT, MDA Federal)**
- Foreign space agencies and U.S. and foreign commercial operators
- **Cloud Service Providers** (Amazon Web Services, Google)
- General Public

Major Operational Programs Using Landsat:

- USDA National Agricultural Statistics Service Crop Type Mapping
- USDA Foreign Agricultural Service Commodity Forecasting
- USDA Risk Management Agency (Crop Insurance)
- USGS/EPA National Land Cover Dataset (NLCD)
- DOI/USDA LANDFIRE Program
- Western States Consumptive Water Use
- NOAA Coastal Change Analysis Program
- Global Forest Watch Forest Change Products



Applications:

- Land use, land cover change
- Agriculture monitoring and forecasting
- Water resource management, availability, quality, usage
- Forest health, forest productivity, wildfire mapping and remediation
- Crop type mapping, yield estimation, efficacy of nutrients and pesticides
- Vegetation dynamics, ecosystem services, rangeland condition
- Land resource management
- Energy exploration and production
- Geologic mapping and mineral resource assessment
- Hazards monitoring and mitigation
- Emergency response, disaster assessment, risk mitigation
- **Reference for instrument calibration**
- **Base data layer for more advanced products**
- Natural resource inventorying and monitoring
- Recreational planning & site suitability analysis
- Urban planning and development